

Claims

- [c1] 1. A method of freeze protection for a fuel cell powered vehicle, the method comprising:
- a) measuring an ambient temperature in the vicinity of a fuel cell vehicle when the fuel cell vehicle has been shut down; and
 - b) providing a flow of moisture-removing medium through the fuel cell when the ambient temperature drops to a predetermined temperature, wherein the medium is flowed through the fuel cell for a sufficient time to remove a sufficient amount of the water in the fuel cell so that the fuel cell is not degraded by freezing of water.
- [c2] 2. The method of claim 1 wherein the step of measuring the ambient temperature is performed continuously or at successive time intervals while the vehicle is shut down until the vehicle is operated.
- [c3] 3. The method of claim 1 wherein the step of measuring the ambient temperature is performed continuously or at successive time intervals until the temperature in the vicinity of the fuel cell drops below the predetermined temperature.

- [c4] 4. The method of claim 1 wherein the step of measuring the ambient temperature is performed by a temperature sensor.
- [c5] 5. The method of claim 2 wherein the temperature sensor is placed in the coolant that precedes the inlet to the fuel cell stack, in the ambient atmosphere adjacent to the fuel cell stacks, or in the water in the fuel cell.
- [c6] 6. The method of claim 2 wherein the temperature sensor is placed exterior to the fuel cell at a location within the vehicle that is correlated to fuel cell temperatures.
- [c7] 7. The method of claim 1 wherein the predetermined temperature is greater than or equal to about 0 °C.
- [c8] 8. The method of claim 1 wherein the predetermined temperature is from about 3 °C to about 7°C.
- [c9] 9. The method of claim 1 wherein the sufficient time for flowing air through the fuel cell is determined to be greater than the time to remove essentially all the water in a fuel cell is measured.
- [c10] 10. The method of claim 1 wherein for a given engine shutdown, the occurrence of the step of flowing air through the fuel cell sets a flag so that if the vehicle warms up above the predetermined temperature and

then subsequently drops below the predetermined temperature step b is not repeated until the engine goes through another start up and shutdown cycle.

[c11] 11. The method of claim 1 wherein the moisture-re-moving medium is air or nitrogen gas.

[c12] 12. A method of removing moisture from a fuel cell, the method comprising:
a) measuring the temperature in the vicinity of a fuel cell vehicle when a vehicle ignition has been turned off; and
b) flowing air through the fuel cell when the ambient temperature drops to a predetermined temperature, wherein the air is flowed through the fuel cell for a sufficient time to remove a sufficient amount of the water in the fuel cell so that the fuel cell is not degraded by freezing of water and the occurrence of the step of flowing air through the fuel cell is remembered by a controller that turns on the air, so that if the vehicle warms up above the predetermined temperature and then subsequently drops below the predetermined temperature step b is not repeated until the engine goes through another turn on and shut down cycle.

[c13] 13. The method of claim 12 wherein the step of measuring the ambient temperature is performed continuously or at successive time intervals while the vehicle is shut

down until the vehicle is operated.

- [c14] 14. The method of claim 12 wherein the step of measuring the ambient temperature is performed continuously or at successive time intervals until the temperature in the vicinity of the fuel cell drops below the predetermined temperature.
- [c15] 15. The method of claim 12 wherein the step of measuring the ambient temperature is performed by a temperature sensor.
- [c16] 16. The method of claim 15 wherein the temperature sensor is placed in the coolant that precedes the inlet to the fuel cell stack, in the ambient atmosphere adjacent to the fuel cell stacks, or in the water in the fuel cell.
- [c17] 17. The method of claim 15 wherein the temperature sensor is placed exterior to the fuel cell at a location within the vehicle that is correlated to fuel cell temperatures.
- [c18] 18. The method of claim 12 wherein the predetermined temperature is greater than or equal to about 0 °C.
- [c19] 19. The method of claim 12 wherein the predetermined temperature is from about 3 °C to about 7°C.
- [c20] 20. A system for removing moisture from a fuel cell in a

vehicle, the system comprising:

a temperature-measuring device to measure the temperature in the vicinity of a fuel cell in a vehicle;

a source of a moisture-removing medium;

a conduit for transporting the moisture-removing medium to the fuel cell; and

a controller that receives temperature data from the temperature sensor, wherein the temperature controller initiates a medium-flowing event in which the moisture-removing medium is flowed through the fuel cell when the ambient temperature drops below a predetermined temperature and wherein the controller remembers that the medium-flowing event has occurred during a given engine shut off period, so that if the vehicle warms up above the predetermined temperature and then subsequently drops below the predetermined temperature a subsequent medium-flowing event is not initiated until the vehicle goes through another engine turn on and shut down cycle.

[c21] 20. The system of claim 19 wherein the temperature sensor measures the ambient temperature continuously or at successive time intervals while the vehicle is shut down until the vehicle is operated.

[c22] 21. The system of claim 19 wherein the temperature sensor is a thermostat element or a thermal switch.

- [c23] 22. The system of claim 19 wherein the temperature sensor is placed in the coolant that precedes the inlet to the fuel cell stack, in the ambient atmosphere adjacent to the fuel cell stacks, or in the water in the fuel cell.
- [c24] 23. The system of claim 12 wherein the temperature sensor is placed exterior to the fuel cell at a location within the vehicle that is correlated to fuel cell temperatures.
- [c25] 24. The system of claim 11 wherein the predetermined temperature is greater than or equal to about 0 °C.
- [c26] 25. The system of claim 11 wherein the predetermined temperature is from about 3 °C to about 7°C.